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# Correlative aspects regarding functional stress and neuromuscular control in high performance aerobic gymnastics – individual events

Aura Bota<sup>\*</sup> and Constanta Urzeală*National University of Physical Education and Sports, 140, Constantin Noica, Bucharest, 060057, Romania*

## Abstract

This paper aims at indentifying the functional stress involved in performing technically difficult elements, in order to optimise their neuromuscular control. Eleven junior gymnasts were investigated, using a heart rate monitor, a standardised simulator and training test, video analyses and the Six Sigma statistical processing method. The heart rate values varied between hard and above maximum intensity levels for all technical elements included in the routines. Computerised training sessions led to a significant statistical improvement in neuromuscular control in performing simplified movements requiring the muscular groups involved in the difficult technical elements which were analysed.

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**Keywords:** aerobic gymnastics; functional stress; neuromuscular control; training methodology.

## 1. Introduction

Romanian aerobic gymnasts have been a constant presence in the world elite since 1990 and we are able to make links between this success and the modern training methodology conceived by the teams' coaches—training which has led to more than 90 medals won in World and European Championships and World Games. During the last few decades, sports science has experienced important changes in terms of the assessment of functional processes and states and such changes are responsible for the remarkable sporting achievements we see today. In this respect, we believe that the only way of studying the subtle aspects of performance components is the multi- or cross-disciplinary approach, including utilizing information from various science domains (physiology, neurosciences, motor control, training methodology, etc.). From the training perspective, the focus seems to be directed on *the biomechanical constraints* which need to be thoroughly analysed in order to determine performance proficiency and on *the functional demands* of the 1min. 30sec. specific effort in the individual events (Bota, 2007; Urzeală, 2006). The present study will focus on both approaches and on the possibility of controlling one's technique under extremely demanding functional stress. Performance aerobic

<sup>\*</sup>Aura Bota. Tel.: +40-074-200-4364

E-mail address: [aurabota@ymail.com](mailto:aurabota@ymail.com)

gymnastics as a highly technical-combinative sport, with complex cinematic elements, requires precise motor control essential to reaching best performance (Schmidt and Lee, 2005). Knowledge concerning physiological costs in competition settings, will help adjusting the training means and methods leading to enhancement of the technical accuracy under functional stress conditions and avoiding trauma or overtraining (Willmore and Costill, 1998).

## **2. Organisation of the research**

### *2.1. Scope*

Our aims are:

- to identify the effort zones for different parts of the routine, expressed by the heart rate values attached to each technical element;
- to assess the efficiency of standardised training under simulator conditions in order to improve neuromuscular control in performing the specific technique.

### *2.2. Subjects*

The sample included 11 gymnasts (12-14 year-old girls) from the National University of Physical Education and Sports Club, who have eight years' sporting experience and have achieved excellent results in national and international competitions.

### *2.3. Methods*

To conduct this research, we used the bibliographical study, the pedagogical observation, a standardised test based on the Ergosim conditions simulator, a heart rate monitor (Polar ProTrainer S625X) and a statistical processing method, six sigma (Pande, Neuman and Cavanagh, 2009) conducted by certified specialists. Heart rate monitors were attached to the gymnasts during two consecutive training routines in order to analyse the specific effort curve in individual events. This curve was correlated with the video-analysed structure of the routine, allowing us to identify the technical elements with the most demanding functional costs and, therefore, most susceptible to be optimised in terms of neuromuscular control. The research took place between September-October 2011, during the pre-season mesocycle, prior to the National Championships.

#### *2.3.1. Test description*

The following test represents both an evaluation tool and a complementary training method for the investigated subjects. The Ergosim system is a technical device used in research, medical recovery and sports training purposes, and it allows the gymnast to visualise in real time during the exercise several movement parameters connected to the neuromuscular control. The gymnasts followed eight computer-based lesson sequences (twice a week, for one month), designed especially for the abdominal muscle groups which are stimulated in the technical elements. Exercise was based on an individualised ideal model of a standardised movement, including the subject's maximal amplitude and the average traction strength. Connected to the computer, the subjects performed the following movement: lying on their back, with thighs flexed at 90 degrees, tractions of the knees to the chest, lifting up the pelvis to a maximum level depending on the individual strength. The subjects' task was to overlap their own graph of their movements' onto the ideal computerised model. Visual feedback was provided during each repetition. The computer evaluated the ability to control the movements with scores given from one to ten. As a training method, the gymnasts performed 2 x 3 series of ten

repetitions, with a load of 50-60% from the maximum strength capacity, with recovery periods of 10-15 min. between the two sequences and 1-2 min. between series.

### 3. Results

The technical elements included in the subjects' routine were attached certain heart rate values, assessed with the Polar Trainer device. Table 1 shows relevant data for one of the gymnasts.

The gymnasts fulfilled their performance objectives by winning the National Aerobic Gymnastics Championship in individual, trio and group events. Also, two of the gymnasts were selected for the junior national team, which took part in the 2012 Aerobic World Championships, where they were ranked in the top eight.

Table 1. Relation between technical elements and functional stress

No.	Technical element	Difficulty group	Heart rate values	Effort intensity	Difficulty quotient
1.	Wenson hinge push up	A - 154	155 - 160	Maximum intensity	0,40
2.	Switch split leap to split	C - 765	185 - 187	Above maximum	0,50
3.	Helicopter to split	A - 305	185 - 187	Above maximum	0,50
4.	Straddle support 1 ½ turn	B - 105	190 - 194	Above maximum	0,50
5.	1 ½ turn tuck jump	C - 265	191 - 193	Above maximum	0,50
6.	Free illusion	D - 195	194 - 196	Above maximum	0,50
7.	1 ½ turn to vertical split	D - 115	196 - 198	Above maximum	0,50
8.	L-support 2/1 turn or more	B - 146	196 - 199	Above maximum	0,60

The heart rate registered values between hard intensity and above maximum intensity (according to the Polar software), for all the technical elements, corresponding to the four groups of the 2012 International Gymnastics Federation (FIG) Code of points:

- Group A Dynamic strength (wenson push up and helicopter families);
- Group B Static strength (straddle support and L-support families);
- Group C Jumps (frontal split and tuck families);
- Group D Balance (turn and illusion families).

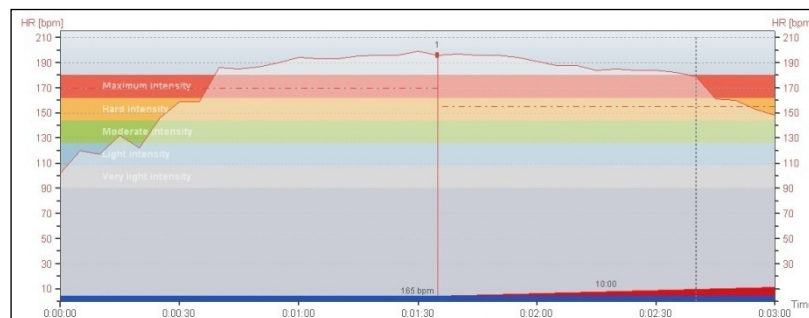


Figure 1. Effort curve for the subject's routine and post-effort recovery

Figure 1 shows that the gymnast performed with heart rate intervals between 110-199 beats/min., with high cumulated plateaus of 185-199 b/min., which, according to the Polar software, signifies an above maximum effort intensity. In the first part of the routine (0-25 sec.), the composition elements gradually raised the heart rate so that the first difficulty element (sec. 25) was performed with 146-150b/min. Between sec. 25 and 57, the gymnast had heart rate values between 187-194b/m., including two difficulty elements from groups A and C. Starting from sec. 57, the subject registered above maximum intensities which determined heart rate values not lower than 193b/min. till the end of the routine. Regardless of the technical group family requesting dynamic, static strength, jumps or balance, the functional stress remained intense for more than 30 sec.; this plateau was also enhanced by the specific step sequences preceding each element. In terms of the recovery capacity, in the first two minutes post-effort, the heart rate lowered to 145b/min., which demonstrates an adequate cardiovascular response according to the training period objectives. From the effort curve perspective we can assert that the subject's routine is a difficult and stressful one, due to the choreographic vision, which implies a high density of technical elements in the second part of the routine. Thus, the most functional stressful (196-199b/min.) but best rated element (0.6points) is placed at the end of the routine, in min. 1.29.

The FIG Code of points requires specific criteria concerning the technical execution, underlining the position and the stability of the upper body, back, limbs, pelvis, abdominal muscles and the whole proper body alignment. Thus, for the leg movements the gymnast must perfectly control the height, angle, plane, range of motion and rhythm change. For the arm movements, also responsible for increasing effort intensity, athletes will master height, angle, plane, range of motion, speed and coordination. Due to the high effort intensity required by most of the technical elements, we presumed that gymnasts might improve their execution accuracy if specific neuromuscular control exercises were added to the traditional training content. With regards to the neuromuscular control, the data collected in the initial testing confirmed an average score of six, on a scale from one to ten. This value corresponded to a sigma level equal to zero, meaning a poor probability in correctly performing the movements (Table 2).

Table 2.Universal Six Sigma scale

Sigma Scale	Probability of efficient movement
6 sigma	99.9997%
5 sigma	99.977%
4 sigma	99.4%
3 sigma	93%
2 sigma	69.2%
1 sigma	31%

The 0 sigma level signifies a normal value, typical for non-athletes but insufficient for gymnasts performing highly technical elements. This poor initial value could be explained by the fact that the simulated movement was performed with an extra load and with a velocity imposed by the Ergosim device, which are not typical in competition settings. Still, this training method is useful to develop both strength and motor control. Below, initial and final average scores are presented, emphasising a significant progress of the neuromuscular control.

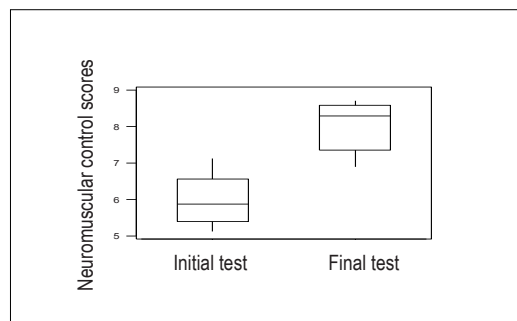


Figure 2. Initial and final neuromuscular control scores

At the final test, the data collected confirmed an average score of 8.11, on a scale from one to ten. This value corresponded to an improved sigma level equal to three, meaning a probability of 93% in performing error-free movements. Figure 3 shows the individual scores of the gymnasts' neuromuscular control parameters, registered in the two testing sessions, proving their significant progress in terms of adjusting strength and amplitude in standardised movements.

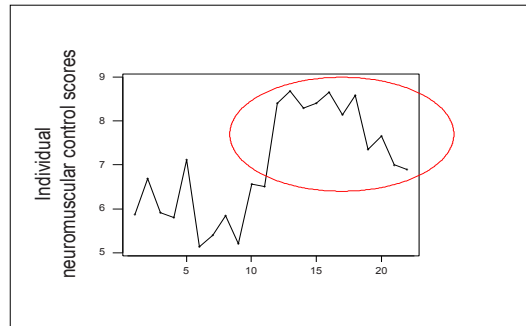


Figure3. Individual scores in initial and final neuromuscular control testing

#### 4. Conclusions

The values of the heart rate proved that in individual events the effort varies between hard intensity and above intensity for all the technical elements included in the routines. This aspect is relevant both in physical and technical training, as the gymnasts have to master their elaborate technique during high intensity routines. This dual constraint imposes the need to find strategies to improve one's neuromuscular control under this extreme functional stress.

A significant statistical improvement in the gymnasts' neuromuscular control occurred by adding the Ergosim -training technology; they are better able to perform simplified movements exerting the muscular groups involved in the complex elements' biomechanics.

The contribution of the complementary Ergosim training was reflected in the gymnasts' results obtained in national and international events, resulting in high execution and difficulty scores awarded by competition judges.

#### References

- Bota, A. (2007). *Kinesiologie*. Bucuresti: EDP.
- Code of points FIG 2009-2012 (2009). Edition March, 137 – 207.
- Pande, P., Neuman, R. & Cavanagh, R. (2009). *Six Sigma*. București: Editura All.
- Schmidt, R., & Lee, T. (2005). Motor control and learning—a behavioral emphasis. *Human Kinetics*, 281 – 286.
- Urzeală, C. (2006). *Efort și solicitare în activitatea sportivă*. Bucuresti: Editura Cartea Universitară.
- Willmore, J.H., & Costill, D.L. (1998). *Physiologie du sport et de l'exercice physique*. Paris – Bruxelles, DeBoeck Universite.